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ABSTRACT

The development of the Mathematics Assessment Questionnaire (MAQ), a survey of thoughts and feelings, for students in grades 7 through 9 is described. The adaptation of the MAQ to an on-line, computer-based administration is also described. This adaptation included the development of a teacher program disk to facilitate teacher access to student responses. The developmental work that led to the computer version of the MAQ included: (1) a feasibility study in 1986-87 that included reviews by experienced mathematics teachers; (2) small-scale studies (1987-88) of the meaningfulness of the metacognitive statements for students and teachers and the type of problem best suited for these statements; (3) a pilot study (spring, 1988) of 300 paper-and-pencil items administered to 1,500 students in New York City public schools; and (4) a large-scale study (fall 1988) involving the administration of 162 paper-and-pencil items to 1,737 students in New York City public schools. The development process indicated that the use of technology for a classroom-level assessment tool has broadened the assessment process for students and added direct communication through notes to teachers. The use of this technology has increased teacher flexible access to information and has encouraged teachers to examine the information from different perspectives. Five tables and six figures illustrate the development process and student beliefs and responses. (SLD)

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A technology-based innovation to facilitate teacher access to and use of assessments of JHS students' self-regulatory, affective and motivational beliefs about mathematics

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A technology-based innovation to facilitate teacher access to and use of assessments of JHS students' self-regulatory, affective and motivational beliefs about mathematics

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In this paper we describe the development of the Mathematics Assessment Questionnaire, A survey of thoughts and feelings(MAQ), for students in grades 7-9, an assessment tool designed for use in JHS mathematics classrooms. We also describe the adaptation of the MAQ to an on-line computer-based administration (IBM compatible, 256k). The computer adaptation of the MAQ includes the development of a teacher program disk to facilitate teacher access to student responses. Adapting to a computer-based administration supports: 1. flexible use by teachers of the MAQ for different groups of students; 2. teacher use of information for individuals or a class; 3. "anchoring" interpretation in the context of the statements to which students respond; and, through a Help feature, ready access to definitions and instructional strategy suggestions.

Development of the Mathematics Assessment Questionnaire

The MAQ is intended to assess selected aspects of JHS students' self-regulatory, affective, motivational and attributional beliefs about doing and learning about mathematical word problems in three classroom activity settings: 1. During class, when the teacher is working with the whole class; With others, when students are working in a small group with other students; and Homework, when students are working independently. The MAQ is intended to complement teacher assessment of student conceptual knowledge and procedural skills in mathematical problem solving. The MAQ focuses on awareness of thoughts and feelings when doing an individual non-routine mathematical word problem, and when learning about and doing problems in each of the three classroom activity settings.

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1 Revised version of a paper presented at the annual meeting of the American Educational Research Association, San Francisco, CA, April 1992. The research and development work reported here has been supported by the Ford Foundation and the Aaron Diamond Foundation.

The focus on classroom-level use of the MAQ led to several decisions. These decisions were: to use classroom activity settings as the context for assessing student perceptions, in order to link more closely with instructional activities; to use a more specific term, mathematical word problems, instead of "mathematics" in statements; and to use smaller sets of statements, since teachers can follow-up and check interpretations of student responses.

The constructs represented in the MAQ computer version (MAQ-CV) are listed in Figure 1. The constructs are: metacognition -- awareness of monitoring, checking, strategy use (assessed following work on a non-routine word problem), 20 items; self-regulatory awareness in each of the three activity settings--19 items During Class, 23 items Working with Others, and 9 items Homework; affective beliefs -- confidence, anxiety, interest, value; motivational beliefs -- internal learning goals, external performance goals; and attributional beliefs -- internal stable controllable and unknown control. There are three-item clusters for each of the constructs in the affective, motivational and attributional beliefs within each activity setting (for a total of 24 items in each setting). There are, then, a total of 143 statements in the MAQ-CV. (The rationale for selecting these constructs is described in Tittle & Hecht 1990, and Hecht & Tittle, 1990; see Selected Related References attached.)

Table 1 presents sample statements from the MAQ-CV, and shows the approach to writing statements that was used for the MAQ. Typically, each statement includes a construct (e.g., anxiety), an activity setting (e.g., During class), and a math term such as "math word problem." Brief definitions for each construct are given in Table 2.

The developmental work that led to the MAQ-CV included: 1. A feasibility study (1986-87), in which related research literature was reviewed, sample statements were written, and experienced JHS mathematics teachers reviewed and evaluated the sample statements; 2. Small-scale studies (1987-88) of the meaningfulness of the metacognitive statements for students and teachers and of the type of problem best suited for these statements; 3. A pilot study, spring 1988, in which 300 sample items were administered (in three forms) in paper and pencil format to 1500 students in grades 7-9 in 14 New York City public schools and one parochial school; 4. A large scale study, fall 1988, in which 162 items were administered in paper and pencil format to 1737 students in grades 7-9 in eight New York City public schools.

During 1989-90 data analyses were carried out, including the development of a criterion-referenced (CRT-

type) scores -- need and strength indicators -- for the affective, motivational and attributional constructs. Summary indicators are provided for the three-item affective, motivational and attributional clusters of statements within each activity setting. The need indicator appears for a student when at least two of the three statements in a cluster are answered in a way to indicate need for teacher follow-up. For example, two of three anxiety statements answered TRUE or VERY TRUE. The strength indicators appears when all of the three statements are answered in a positive direction. Interpretations of the need and strength indicators are in Table 3; a sample calculation in Table 4.

In 1990-91 and 1991-92 the MAQ was adapted to a computer-based administration (Student disk, the SMAQ) and the teacher program was developed (Teacher disk, the TMAQ). As described earlier, there are currently 143 statements in the MAQ-CV. The student (SMAQ) and teacher (TMAQ) disks are now in a field trial (1992), with student and teacher evaluation data being collected.

Demonstration of the MAQ-CV: Student and Teacher Program Disks

The main features of the SMAQ and TMAQ are listed in Figures 2 and 3. For the student disk, the program has the following features:

- a separate survey disk is used for each student
- a menu presents a choice of sections to start the survey
- a summary keeps track of the number of statements completed for each section
- a procedure is available to review/change responses
- a NOTEBOOK feature is available to encourage students to write to their teachers at any place in the survey,
- a NOTEBOOK record is kept of the MAQ location where the note is made
- a Riddle appears when any MAQ section is completed

For the teacher disk, the program has these features:

- a data section, that assembles class results and
- an edit feature for student data that identifies possible questionable response patterns
- a utility feature that supports changing math problems in the metacognitive section
- a menu-driven exploration of student and class responses including student notes in the NOTEBOOK
- a HELP feature that includes definitions of terms, survey statements, questions to consider, and instructional strategies

Figures 4 and 5 present flow charts for the SMAQ and TMAQ, respectively, identifying the main features of each. Figure 6 presents the flow chart for the TMAQ Help Screen. The TMAQ HELP menu is always available through a dedicated function key.

As indicated in Figure 5, the user can decide to look at information for a class (CLASS), a group of students, or for individual students (STUDENT). The information can always be examined statement-by-statement and the CRT-type need and strength indicators are also available for individual students and for a class.

As Figure 6 shows, the options for the HELP feature include: a definition of the construct and the statements in the survey, and suggested instructional strategies. The suggestions were developed in collaboration with mathematics teachers and mathematics teacher educators.

Discussion

The use of technology for administering the MAQ has some benefits for students in encouraging a self-paced reading of the statements. The technology also supports writing about thoughts and feeling in learning mathematics, and communicating the writing to teachers. To date we have worked with a small set of teachers (5) who have used different ways to administer the MAQ: a class in a computer lab during math period; individual students working before or after school in a computer lab; a remedial math lab of ninth grade students reading the questions aloud and asking questions if a statement was not clear, including a bilingual student translating for others; and one-on-one with an individual student, with the student talking aloud about the statements as well as entering responses to statements.

From the perspective of class-level assessment, any and all of these uses are appropriate. Teachers can identify particular statements and use them for class or group discussions. There are no "norms," standardized procedures or right and wrong answers. The goal is for the computer technology to support teacher access to systematic assessment information, and to support teacher exploration of the student information. How teachers explore the information and the meaning and use they make of the information is a key question for us.

We are now doing "talk-aloud" or think aloud procedures with teachers looking at the responses of students in their classes, as earlier we did a similar procedure for students responding to the MAQ. Table 5 provides a partial transcript of one student doing a "talk aloud" with the MAQ.

Table 5 also provides a partial transcript of a teacher looking at her own class data, including some of the interpretations and instructional suggestions she made.

The transcripts suggest the research opportunity the technology-based assessment provides. We can work on understanding student thinking about learning in different mathematics classroom activity settings incorporating these other perspectives, of their feelings, motivations, and awareness of their self-regulatory thoughts. We can also work on understanding the meanings teachers construct from these responses, particularly as these meanings relate to classroom instructional planning.

In summary, the use of technology for a classroom-level assessment tool has broadened the assessment process for students--adding direct communication through notes to teachers. The use of technology has greatly expanded teacher flexible access to information, and in fact encourages teachers to examine the information from different perspectives. Further, the technology has supported integrating instructional suggestions for access by teachers when looking at student responses.

The limitations in the example of the MAQ are the psychometric theory with which we started and the indirect assessment of these important attitudinal and self-regulatory constructs. By this we mean that we do not have a psychometric theory that is integrated with a cognitive perspective and the assessment process is isolated from on-going instructional activities. However, we have started to examine, from one perspective, the process of looking at how students and teachers think and feel about some aspects of learning and doing mathematical word problems in JHS classrooms. The computer-based teacher program provides an unusual opportunity to study teachers' thoughts about student assessment information, in the context of their own students' responses, in an area that has received little classroom attention in assessment--the self-regulatory, affective and motivational beliefs of students.

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Table 1

Sample Statements from the Mathematics Assessment Questionnaire Illustrating Constructs and Classroom Activity Settings

Self regulation: During class	When I can think of another way to solve a word problem, I volunteer to show the class.
Self regulation: Working with others	I say to the other students if I think something should be worked differently.
Self regulation: Homework	I decide when is the best time to do my math homework word problems.
Anxiety: During Class	I get scared when I have to work a word problem on the board.
Anxiety: Working with others	I dread the thought of trying to solve a math word problem with other students.
Anxiety: Homework	I feel relaxed when I am doing word problems at home.
Internal learning goals: Homework	I like to do hard homework math word problems because I learn more math by working them.

Table 2

Definitions of Beliefs in the MAQ

Metacognition: self-awareness of what done and strategies used when working a specific non-routine word problem.

Self-Regulation: awareness of self-directed strategies to learn as related to working mathematical word problems in the classroom activity setting.

- -

Value: the conviction that learning about mathematical word problems is worthwhile, useful or important.

Interest: the liking to work or learn about mathematical word problems.

Confidence: the belief in one's ability to do or learn mathematical word problems.

Anxiety: worry, uneasiness or fear about doing or learning mathematical word problems.

Internal Learning Goals: internal or intrinsic motivations for learning of mathematical word problems -- one finds it personally challenging and valuable.

External Performance Goals: external motivations for learning mathematical word problems -- one is motivated by grades or teacher approval.

Internal Stable Controllable: an attribution of success (During Class, Homework) or failure (Working With Others) for doing or understanding mathematical word problems to a cause which is internal AND changeable -- e.g., effort.

Unknown Control: perceived confusion or inability to make sense out of why one succeeds or fails at doing mathematical word problems.

Table 3

General interpretation of MAQ NEED and STRENGTH Indicators

	Need Indicators	Strength Indicators
Affective Beliefs:		
Value	low	high
Interest	low	high
Confidence	low	high
Anxiety	high	low
Motivational Beliefs (to learn/do):		
Internal Learning Goals	low	high
External Learning Goals	high	low
Attributional Beliefs (causes of success/failure):		
Internal Stable Controllable (e.g., effort)	low	high
Unknown Control confused about causes	high	*

* Strength indicators are not relevant for Unknown Control.

Table 4

An example of the calculation of a "Need Indicator": Anxiety-Homework
(* is the student's response)

	VERY TRUE	TRUE	SORT OF TRUE	NOT VERY TRUE	NOT AT ALL TRUE
17. I feel nervous when I think about doing hard word problems for homework.	*				
23. I feel relaxed when I am doing math word problems at home.					*
31. Doing word problems for homework does not make me nervous.			*		

The student reports feeling anxious on two statements, indicated by a response in one of the two extreme categories--(Item 17, a VERY TRUE response; Item 23, a NOT AT ALL TRUE response); On Item 31 the student does not report feeling anxious.

NEED is indicated since the student responded to AT LEAST TWO of the statements in a way to suggest ANXIETY.

NEED is indicated when a student responds to AT LEAST TWO of the three statements in a way to suggest the need for follow-up (e.g., ANXIETY). STRENGTH is indicated when a student responds to ALL THREE statements in a way to suggest a strength (e.g, a LACK OF ANXIETY).

Table 5

Computer Version
Mathematics Assessment Questionnaire:
Teacher and Student "Talk Alouds"

Teacher

"This is what I like best about this program. This is interesting, because this kid is uncomfortable during instruction, but he doesn't show up here (pointing to the homework setting). He's very introverted, but at home I guess he can do math better than he can in school. (She reviews other students who have a need with regard to Anxiety in the During Class and Working With Others settings). If it's really true that they're anxious during instruction, I'm not sure if it has something to do with being called on to go to the board, or putting them in situations with other students where they don't feel they can either handle it or perform well, and if that were the case, I would probably try to arrange a different situation for them. Instead of just randomly calling them to the board, I may go over and work with them a little bit before the lesson starts so that they feel they have a grasp on it, so then I can call them to participate, and go to the board and get some positive feedback. I may try then to put them with other students that maybe are also anxious that need more help, where they can take charge a little bit, or something. But what happens with some of these students is because they're anxious, they're very difficult, they have a tendency to be dismissed as troublemakers, because you don't have time for all of them.

Student: Activity setting: DURING CLASS

Statement: I am afraid when I have to ask my math teacher a question about a word problem during class.
Student response: "afraid. Well, sometimes I'm like afraid because if everyone else seems like they have gotten it and like I'm totally lost it could be kind of embarrassing. That used to happen, but not always, so it is sort of true ... sometimes if I'm just like lost I don't want to raise my hand or anything because I am afraid I'll be branded. If it is important and I don't understand it, like it is the day before a test, then I will just raise my hand... so I guess it is sort of true."

Activity setting: WORKING WITH OTHER STUDENTS

Statement: I dread the thought of trying to solve a math word problem with other students.
Student response: "not at all true, because you can learn more that way."

Activity setting: HOMEWORK

Statement: I feel nervous when I think about doing hard word problems for homework.
Student response: "...I feel kind of nervous...cause I want to show that at least I can do good effort."

Figure 1

Domain Specifications for the Mathematics Assessment Questionnaire
Two Facets: Psychological Construct and Setting

CONSTRUCT	
Metacognitive: Solving a math problem .Planning, defining objectives .Monitoring progress .Checking & evaluating .Strategies employed	METACOGNITIVE ITEMS NOT LINKED TO SPECIFIC SETTING LINKED TO SPECIFIC PROBLEM

	ACTIVITY SETTING		
CONSTRUCT	During Class	Working with Others	Doing Homework
Self-regulation .awareness of self-directed strategies to learn and work (varies depending upon setting)			
Affective Beliefs			
.Value, utility			
.Interest			
.Confidence			
.Anxiety			
Motivations			
.Internal Learning Goals			
.External Performance Goals			
Attributions			
.Internal Stable Controllable			
.Unknown Control			

Figure 2

Features of Student Disk: SMAQ
Mathematics Assessment Questionnaire-CV

- A separate disk is used for each student
- A flexible and varied use questionnaire disk
  --Use on different days
  --Use with individual students or a class
  --Use one-on-one, with a think-aloud procedure
- A menu presents a choice of sections to start
- A summary keeps track of the statements completed for each section
- A procedure is available to review/change responses
- A NOTEBOOK feature is available to encourage students to write to teachers at any time
- A NOTEBOOK record is kept of the MAQ location where the note is made
- A riddle appears when any MAQ section is completed

Figure 3

Features of Teacher Program Disk: TMAQ

- A program designed for easy access to student and class responses
- A data section, that assembles class results and
- A feature for editing student data that identifies possible questionable response patterns
- A utility feature to support changing mathematics problems in the metacognitive section
- A menu-driven exploration of student and class responses including student notes in the NOTEBOOK
- A HELP feature that includes
  --definitions of terms
  --questionnaire statements
  --questions to consider and
  --instructional strategies to try
- A print-screen feature

Figure 4

Flow Chart of SMAQ

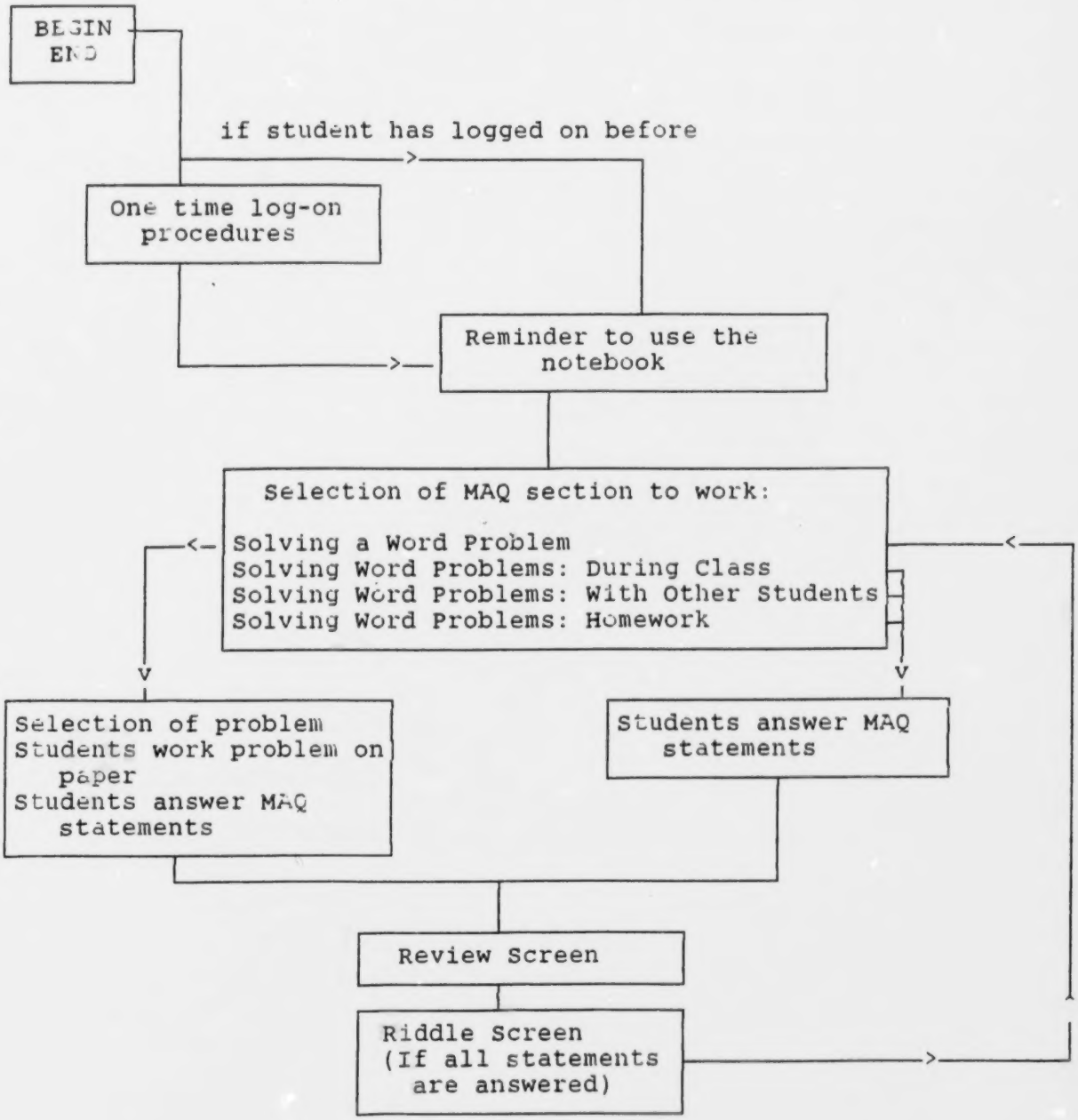


Figure 5

Flow Chart of TMAQ

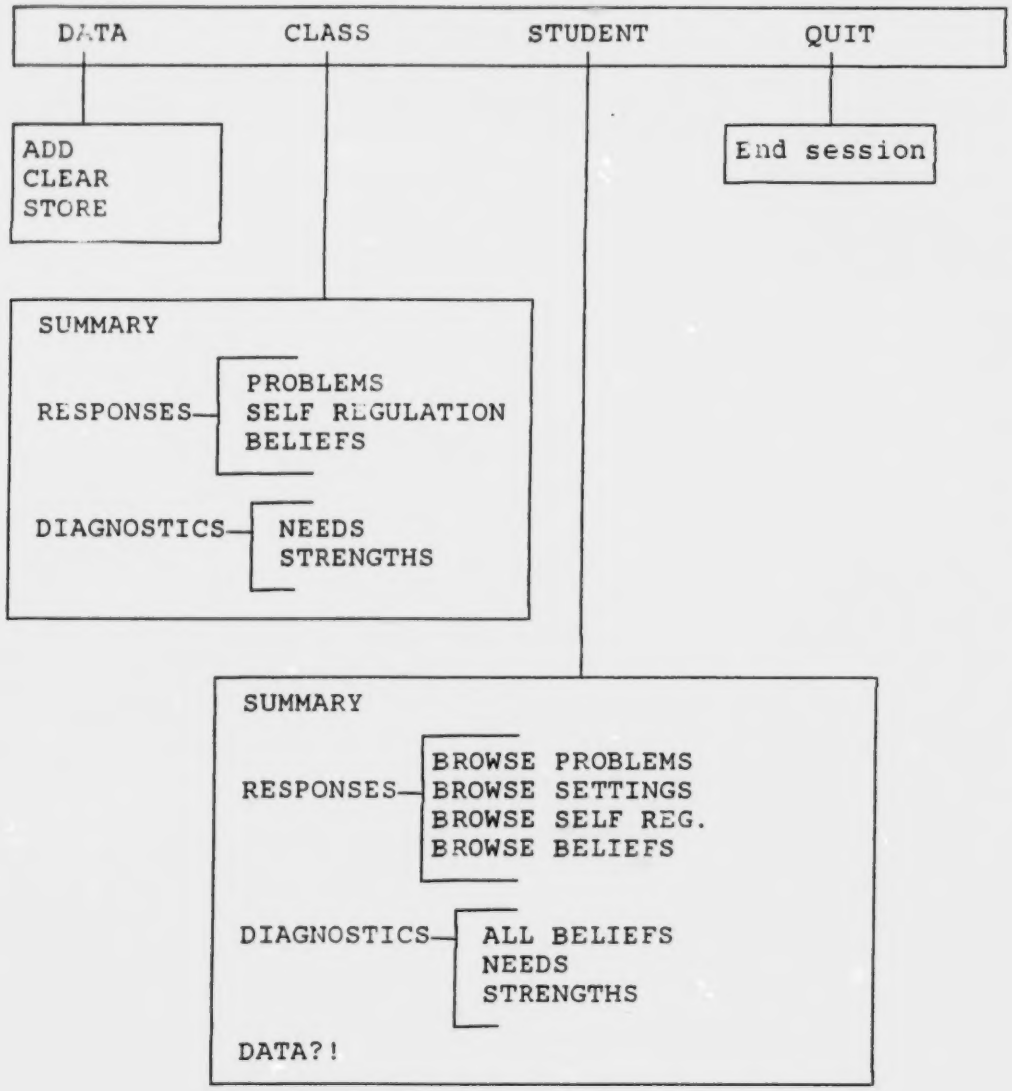
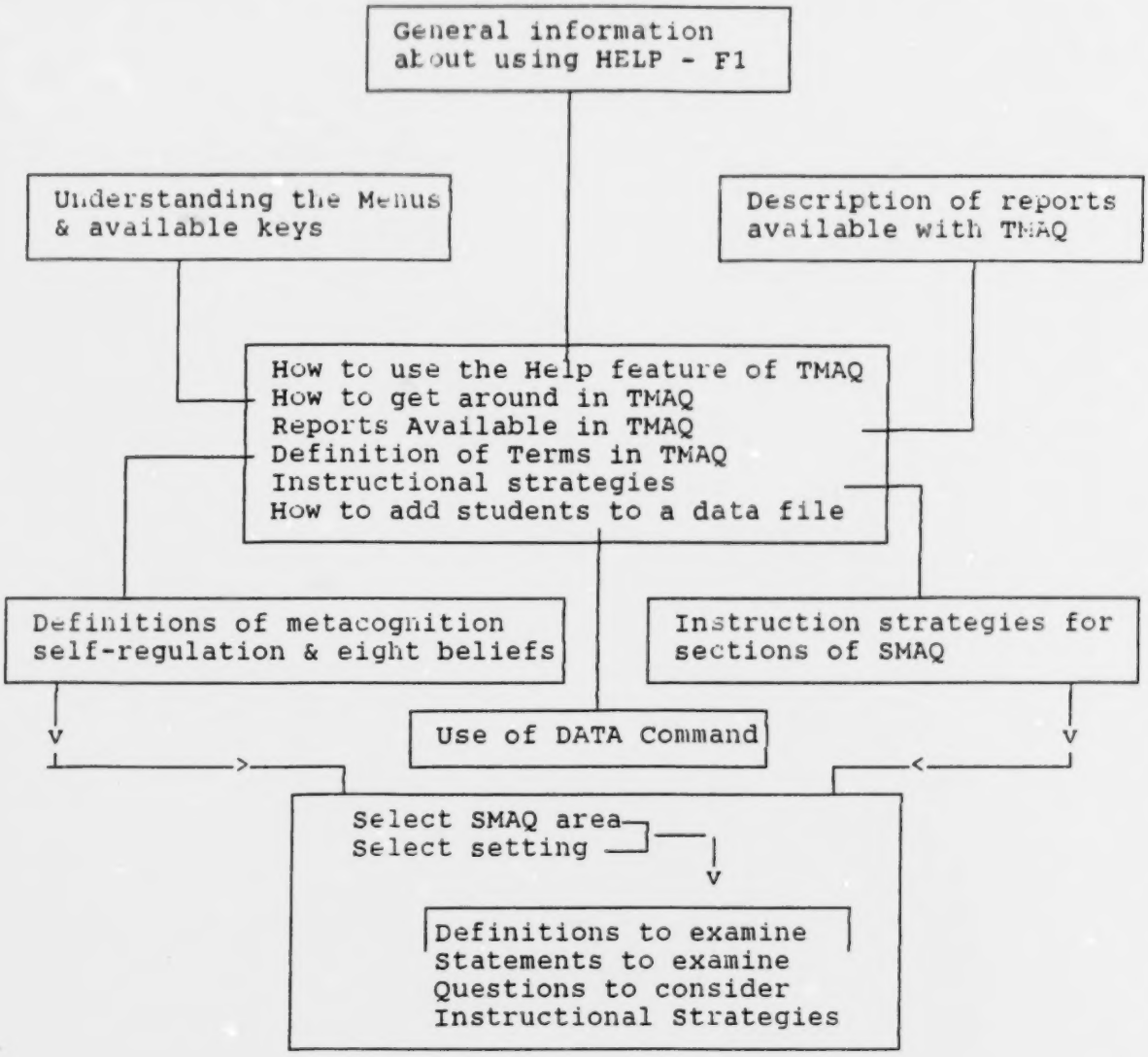


Figure 6

Flow Chart of TMAQ Help Screens - F1 KEY


General information about using HELP - F1
Understanding the Menus & available keys
Description of reports available with TMAQ
How to use the Help feature of TMAQ
How to get around in TMAQ
Reports Available in TMAQ
Definition of Terms in TMAQ
Instructional strategies
How to add students to a data file
Definitions of metacognition self-regulation & eight beliefs
Instruction strategies for sections of SMAQ
Use of DATA Command
Select SMAQ area
Select setting
Definitions to examine
Statements to examine
Questions to consider
Instructional Strategies